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PERFORMANCE EVALUATION OF TRACTOR OPERATED ROTAVATOR IN DRY LAND AND WET LAND FIELD CONDITION

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ABSTRACT

Rotavator plays a vital role in helping the farmer to plough their land in a much faster and effective way. An attempt has been made to evaluate the performance of rotavator in dry land wet land condition. Wear analysis of blade was carried out for better life and performance in field. Hence any improvement in the field performance of the same would in turn, augment the productivity in the agricultural sector. From the study it was observed that the wetland operation required one or two passes to get desirable puddling index. The rate of work in dry land operation of rotavator while working in medium black soil was found in range of 0.330-0.350 ha/h where as the depth of operation was found as 9.85-10.21cm in dry land condition. The field efficiency of rotavator was recorded as 77.18-80.60 %. The depth of puddle and puddling index was recorded as 19.68-20.25cm and 78.84-80.63 %, respectively.

KEYWORDS: Rotavator, Puddling Index, Blades, Wear Analysis

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Research Article

INTRODUCTION

India ranks second worldwide in agricultural farm output. India has shown a steady average nationwide annual increase in the kilograms produced per hectare for various crops, over the last 60 years. One of the main contributing factors for the steady growth is the onset of mechanization of the farm equipments leading to a steady increase in the yield output of the farmers. Tillage is the most important operation in agriculture. Now a day's most of the Indian farmers are using tractor drawn improved agricultural implements and machinery for different operations in the field for primary tillage operations implements like MB plough, Disc plough, Rotary ploughs is used whereas for the secondary tillage operations implements like offset disc harrow, cultivators, blade harrows and rotavators are using. In recent years rotavator is becoming popular among the farmers for land preparation where two or more corps are taken in a year. Rotavator can play an important role in double or multiple cropping systems where the time for land preparation is limited. Whereas in MB plough, Disc plough cultivator and disc harrow during tillage operations energy consumption is comparatively more. It is done mainly to loosen the upper layer of soil to mix the soil with fertilizer and to remove weeds. The rotavator will produce a perfect seedbed in fewer passes. It is the ideal implement for farmers who need to bury and incorporate crop residues quickly, between crops. Tillage tools direct energy into the soil to cause some desired effect such as cutting, breaking, inversion, or movement of soil. Soil is transferred from an initial condition to a different condition by this process. A rotavator is a mechanical gardening tool with power blades attached to a spinning surface to plough soil and produce optimum tillage. In the aspects of saving power consumption and improving energy saving of agricultural machinery during soil cultivation, many scholars made a lot of research and practice on the influences of turning direction of rotary

tool to cultivation and energy saving effect (Manian and Kathirvel, 2001; Prasad, 1996).

Rotary tiller or ROTAVATOR (derived from rotary cultivator) is a tillage machine designed for preparing land by breaking the soil with the help of rotating blades suitable for sowing seeds (without overturning of the soil). It also plays a vital role in eradicating weeds, mixing manure or fertilizer into soil, to break up and renovate pastures for crushing clods etc. It offers an advantage of rapid seedbed preparation and reduced draft compared to conventional tillage. The first rotavator was introduced in US by a Swiss manufacturer in 1930s. Rotavator action involves the direct application of tractor engine power through a rotor and blades of a special design to soil preparation in establishing the ideal growth conditions for seedlings and seeds. In this investigation, the work is done towards performance of rotavator in dry land and wet land field.

MATERIALS AND METHODS

The performance trials of tractor operated rotavator were taken in dry and wet land condition for the it's feasibility at University field (Dr. PDKV, Akola) as well as farmer field. The functional components of rotavator are rotar blade, rotor shaft, flanges, and hitch pyramids, skid, and adjusting rack, trailing boards, gear box and shield. Details specifications of the rotavator are given in table 1. The isometric view of rotavator is shown in Figure 1.

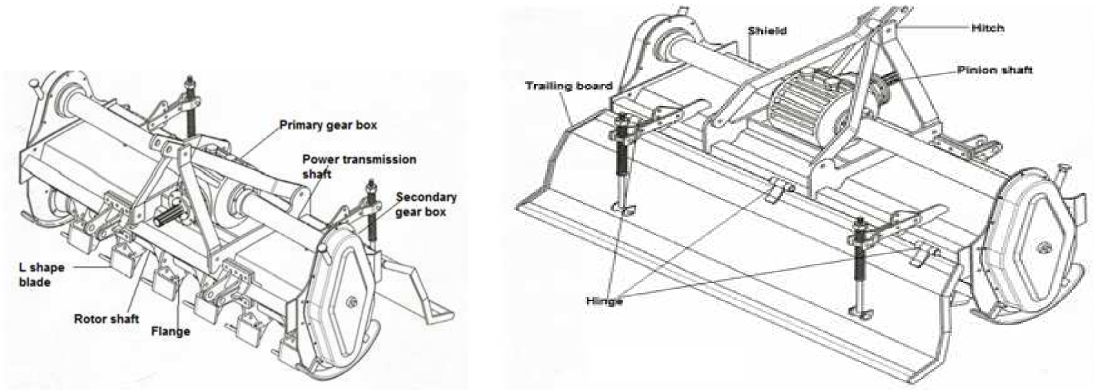

Figure 1: Isometric View of Tractor Operated Rotavator

Table 1: Specification of Tractor Operated Rotavator

S. No.	Particulars	Specifications
1	**Chasis**	
	Type and Size of box section, (mm)	Rectangular type & M.S. Hollow Square Tube of size 1560x60x60 (LxWxH)
2	**Shield (Cover)**	
	Type and Size, (mm)	Rectangular type and1560 x 580 x 3.5 (LxBxT)
3	**Trailing Board:**	
	Type	Curved type
	Size of board, (LxBxT) (mm)	1775 x 510(curved)x3.5
	Type and no. of hinges of hinge	Pivot hinge an d 3 Nos
4	**Rotor Shaft:**	
	Type of rotor axle & Size of shaft,	Straight & Length: 1415 and OD: 90 ϕ
	Types and No. of flanges	Circular and 6 no.
	Dia. of flange, (mm)	236 ϕ
	No. of blades on each flange	6 blades on each flange.
	Distance between two flanges, (mm)	250
	Total no. of blades	36
	Dia. of rotor with blades, (mm)	410

Table 1: Contd.,

5	**Rotor Blade:**	
	Number	36
	Type & Material	L Shape blade & Mild steel
	Overall thickness, (mm)	7
	Thickness at beveled edge, (mm)	2.2
	Length of the beveled edge, (mm)	225
	Speed of rotor shaft corresponding to 540 rpm of PTO shaft, (rpm)	209
	Peripheral speed of rotor blades, (m/s)	4.48
6	**Skid (Depth Control Mechanism)**	
	Type & Material	Curved Shape, M.S. Flat Single Plate
	Size, (LxBxT) (mm)	580 x 70 x 12
7	**Adjusting Rack**	
	Type & material	Rectangular type, M.S.
	Size, (mm)	120x40x8
	Range of depth adjustment, (mm)	Up to 160
8	**Gear Box Assembly (Primary Reduction):**	
	Type	Bevel and spur gear
	No. of teeth on pinion	11
	No. of teeth on bevel gear	25
	Speed reduction ratio at gear box	0.44
	Dia. of shaft, (mm)	44
9	**Gear Box (Two Secondary Reduction):**	
	Type and no. of gears	Constant mesh type and e 3
	No. of teeth on drive gear	23
	No. of teeth on driven gear	26
	No. of teeth on Idle gear	36
	Reduction ratio	0.88
	Propeller Shaft:	
	Length of the shaft, (Maximum) mm	400
	Mass of shaft, (kg)	16.75
10	Overall Dimensions (L x W x H)	1775 x 1110 x 1125
11	Mass of the Machine, (kg)	475

Performance Evaluation of Rotavator

During the performance test of rotavator methodology followed as per IS: 11531-2001 and IS: 6690-2002 and different observation were taken for assessment of the machine performance. The more than one hectare area of the test plot was selected. The ratio of width and length of the plot was as possible as 1:2. The plot selected plot for the wet land operation reasonably leveled and slope did not exceed 1 percent. Minimum 7 cm of water column was maintained in the test plot. After the watering of the plot for puddling, height of standing water above the ground surface, bulk density various places and infiltration rate measurement taken before wet land test of rotavator.

Following different parameters were noted at a time of field evaluation of rotavator

Soil Moisture Content: Soil moisture content on dry basis was measured by as suggested by Mohsenin (1979) using oven dry method. Five samples of soil were collected randomly from test plots, weight of each samples was taken using an electronic balance. Then these samples were kept in hot air oven maintaining temperature 105 ^{0}C degree for 24 hours. After that, samples were taken out from oven and kept in desiccators. The borne dry weight of sample was recorded

by using electronic balance. The moisture content on dry basis was calculated using following formula.

$$\text{Moisture content (\%)} = \frac{w_1 - w_2}{w_2} \text{x}100 \tag{1}$$

Where,

w_1 = initial weight of soil sample, g

w_2 = borne dry weight of soil sample, g

Bulk Density: It is the ratio of mass of soil sample to the volume of core cutter. The bulk density of soil was determined by the procedure explained by Mohsenin, (1979). Three soil samples were collected at the different locations randomly selected in the test plot using cylindrical core sample. The diameter and length of cylindrical soil samples were measured. The soil samples were kept in hot air oven maintained at 105 ^0C for 24 hour. After that, soil sample were taken out and kept in desiccators. The borne dry weight of soil samples was measured. The bulk density of soil was calculated by following formula.

$$\text{Bulk density(g/cm}^3) = \frac{\text{Mass of soil sample}}{\text{Volume of core cutter}} \tag{2}$$

$$= \frac{M}{\pi D^2 L}$$

Where,

ρ = bulk density, gm/cm^3

M = borne dry weight of soil sample, g

D = diameter of cylindrical core sampler, cm

L = length of cylindrical core sampler, cm

Travelling Speed (km/hr): For calculating traveling speed two poles 20 m apart was placed approximately in middle of the test run. On the opposite side also two poles were placed in similar position, 20m apart so that four poles forms corners of rectangle, parallel on long side of the plot. The speed was calculated from the time required for machine to travel the distance (20 m) between two poles. Average of such reading was taken to calculate the travelling speed of self propelled weeder. The forward speed of operation was calculated by observing the distance traveled and time taken and calculated by following formula (Mehta *et al.*, 2005).

$$S = \frac{L}{t} \tag{3}$$

Where,

S = forward speed of machine, m/s

L = distance travelled, m

t = time taken, s

Theoretical Field Capacity: For calculating the theoretical filed capacity, working width and travelling speed were taken in to consideration. It is always greater than the actual field capacity.

Theoretical field capacity was calculated by using following formula (Mehta *et al.*, 2005).

$$T.F.C. = \frac{S \times W}{10} \quad (4)$$

Where,

T.F.C. = theoretical field capacity (ha/hr)

W = theoretical width of weeder (m)

S = speed of operation (km/h

Effective Field Capacity: For calculating effective field capacity, the time consumed for actual work and lost for other activities such as turning and cleaning blade when clogged with weeds were taken in to consideration. Effective actual field capacity was calculated by following formula (Mehta *et al.*, 2005).

$$E.F.C. = \frac{A}{T_p + T_1} \quad (5)$$

Where,

E.F.C. = effective field capacity (ha/hr)

A = area (ha)

T_p = productive time (hr)

T_1 = non productive time, hr (Time loss for turning and cleaning blades)

Field Efficiency: Field efficiency was calculated by taking ratio of effective field capacity to theoretical field capacity. It is always expressed in percentage.

It was calculated by following formula (Mehta et *al.*, 2005).

$$\text{Field efficiency (\%)} = \frac{\text{E.F.C.}}{\text{T.F.C.}} \times 100 \quad (6)$$

Where,

E.F.C. = effective field capacity

T.F.C. = theoretical field capacity

Fuel Consumption: Fuel consumption was quantified by adopting standard procedure. The fuel tank was filled to its full capacity before and after the test. Amount of refueling after the test was measured which was the actual fuel

consumption for test.

Fuel consumption was measured by recording time required and the quantity of fuel consumed for specified length of run and the fuel consumption was calculated on hourly basis as follows (Mehta *et al.*, 2005).

$$W_f = \frac{36 \times V_f \times 10^{-4}}{T} \tag{7}$$

Where,

W_f = fuel consumed, m^3/h

V_f = volume of fuel consumed for specified run, cc

T = time taken to cover specified length of run, s

Depth of Puddling: A special probe of 25.4 mm diameter and 100mm long graduated in millimetres was used to measure depth of puddling by penetrating vertically. The depth at which the fore required to push the rod manually, increases by 2 kg was taken as the depth of puddle.

Puddling Index: For the determining the puddling index sample of soil water suspension was taken by immersing the glass tube to the depth about 100 mm. The samples were taken from the number of location and collected in measuring cylinders. These were kept undisturbed for 48 hrs to allow the soil to settle. The volume of settled soil was noted for computing the puddling index.

Puddling index was determined by following formula (IS: 11531-1985)

Puddling index= (Vs/V) x100 (8)

Where,

Vs = Volume of settle soil, and

V = total volume of sample

Height of Standing Water: Height of standing water over puddle field was measured accurately steel scale

RESULTS AND DISCUSSIONS

Tractor operated rotavator evaluated at dry land and wet land condition. The wear analysis of rotor blades on dimension basis was also carried out in both conditions. The field test of rotavator comprising of dry and wetland operation were conducted for 24.15 and 17.75 hours respectively in different moisture conditions to assess the performance of the implements.

There were six trials were carried out at the dry land field and four trials in wet land field. The performance result of the rotavator at dry land condition and wet land condition is presented in table 2 and 3 respectively.

Table 2: Performance Result of Rotavator in Dry Land Field

S. No.	Parameters	Test Trials					
		I	II	III	IV	V	VI
1	Duration of test (h)	3.71	4.83	3.78	4.70	3.12	4.01

Table 2: Contd.,							
2	Furrow length (m)	149	178	139	162	127	180
3	Type of soil	Medium black soil					
4	Bulk density (g/cc)	1.38	1.35	1.31	1.29	1.32	1.35
5	Soil moisture (%)	12.49	13.04	13.71	12.06	12.70	13.21
6	Forward speed (km/h)	3.00	2.97	2.93	3.02	2.88	3.1
7	Wheel slip, (%)	-2.31	-1.78	-1.89	-2.41	-1.76	-2.62
8	Av. depth of cut (cm)	9.93	10.00	10.03	9.90	10.21	9.85
9	Av. width of cut (cm)	143.82	144.12	145.31	142.80	148.00	142.31
10	Area covered (ha/h)	0.333	0.345	0.331	0.341	0.330	0.350
11	Time required for one ha (h)	3.00	2.90	3.02	2.93	3.03	2.86
12	Field efficiency (%)	77.18	80.60	77.51	79.07	77.42	79.34
13	Fuel consumption (l/h)	4.59	4.63	4.65	4.57	4.79	4.54
14	Fuel consumption (l/ha)	13.78	13.42	14.05	13.40	14.52	12.97

Table 3: Performance Result of Rotavator in Wet Land Condition

S. No.	Parameters	Test Trials			
		I	II	III	IV
1	Duration of test (h)	4.37	3.71	5.03	4.64
2	Type of soil	Medium black soil			
3	Previous treatment	Ploughed land			
4	Av. Forward speed (km/h)	2.48	2.62	2.53	2.59
5	Av. travel reduction (%)	3.71	2.25	2.33	2.32
6	Av. depth of standing water (cm)	10.3	10.08	10.00	9.99
7	Water over puddle (cm)	3.61	3.27	3.32	3.65
8	Av. depth puddle (cm)	20.25	19.80	19.92	19.68
9	Av. wheel sink age (cm)	20.49	20.35	19.86	21.01
10	Puddling index (%)	80.20	78.84	79.36	80.63
11	Fuel consumption (l/h)	4.83	4.74	4.80	4.77

Table 2 and 3 depicted the performance result of rotavator which is summarized below

Test Result in Dry Land Condition

The rate of work of rotavator in medium black soil was found as in range of 0.330-0.350 ha/h and the forward speed of 2.88-3.1km/h. The time required to cover one hectare area was recorded as 2.90-3.03 h. The depth of operation was found as 9.85-10.21cm. The field efficiency was recorded as 77.18-80.60 %.

Test Result in Wet Land Condition

The forward speed of operation of rotavator was found in the range 2.48-2.62 km/h in wet land condition. The depth of puddle and Puddling index was recorded as 19.68-20.25cm and 78.84-80.63 %, respectively.

Wear Analysis of Rotavator Blade

Wear analysis of the rotavator blade on the dimension basis was carried out in dry land and wet land condition. Wear of blades of rotavator is presented in table 4 and 5 in dry land and wet land condition respectively.

Table 4: Wear of Blades on Dimension Basis in Dry Land Operation

Sr. No.	Initial Width at (mm)			Width After 24.15 h (mm)			% Wear After 24.15 h			% Wear Per h		
	A	B	C	A	B	C	A	B	C	A	B	C
1	80.03	82.12	84.34	77.68	79.09	82.43	2.94	3.69	2.26	0.12	0.15	0.09
2	79.28	82.31	84.05	77.24	79.21	81.97	2.57	3.77	2.47	0.11	0.16	0.10

Table 4: Contd.,

3	79.43	81.36	84.37	75.79	78.23	82.31	4.58	3.85	2.44	0.19	0.16	0.10
4	80.42	82.00	83.19	76.76	80.58	80.45	4.55	1.73	3.29	0.19	0.07	0.14
5	79.28	81.23	84.05	75.8	78.66	82.03	4.39	3.16	2.40	0.18	0.13	0.10
6	80.04	82.7	84.15	76.85	78.92	81.53	3.99	4.57	3.11	0.17	0.19	0.13

Table 5: Wear of Blades on Dimension Basis in Wet Land Operation

Sr. No.	Initial Width at (mm)			Width After 17.75 h (mm)			% Wear After 17.75h			% Wear Per h		
	A	B	C	A	B	C	A	B	C	A	B	C
1	77.68	79.09	82.43	76.03	76.88	81.73	2.12	2.79	0.85	0.12	0.16	0.05
2	77.24	79.21	81.97	74.91	78.33	80.67	3.02	1.11	1.59	0.17	0.06	0.09
3	75.79	78.23	82.31	73.67	77.09	81.01	2.80	1.46	1.58	0.16	0.08	0.09
4	76.76	80.58	80.45	74.59	78.07	79.34	2.83	3.11	1.38	0.16	0.18	0.08
5	75.8	78.66	82.03	73.72	77.59	79.69	2.74	1.36	2.85	0.15	0.08	0.16
6	76.85	78.92	81.53	74.57	77.57	78.88	2.97	1.71	3.25	0.17	0.10	0.18

Table 4 an5 depicted that, the hourly percentage wear of the blade on dimensional basis was recorded as 0.07 to 0.19 percent in dry land operation. The hourly percentage wear of the blade on dimensional basis was recorded as 0.05 to 0.18 percent in wet land operation.

Effectiveness of Sealing's

After the completion of field test in wetland operation for 17.75 h the rotavator was dismantled for checking the effectiveness of sealing provided against ingress of dust and water/mud in various sub-assemblies and also checks the condition of components of the rotavator. Ingress mud or water was not found in primary reduction gear box, secondary reduction gear box and rotary axle bearing cap.

CONCLUSIONS

From the feasibility trials of rotavator in field following conclusion could be drawn

- The wetland operation required one or two passes to get desirable puddling index.
- The operator can easily adjust and control the rotavator from the operator's seat in the field as the adjustments are within the reach of operator. However the operator has to get down from the tractor in order to raise/lower the depth adjusting skid.
- The rate of work of rotavator in medium black soil was found as in range of 0.330-0.350 ha/h.
- The depth of operation was found as 9.85-10.21cm in dry land condition.
- The field efficiency of rotavator was recorded as 77.18-80.60 %.
- The depth of puddle and Puddling index was recorded as 19.68-20.25cm and 78.84-80.63 %, respectively.

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